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E X P E R I M E N T S

RELATING TO

ANIMAL ELECTRICITY;

FROM THE

T R A N S A C T I O N S

OF THE

*ROYAL SOCIETY OF EDINBURGH.*

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EXPERIMENTS *relating* to ANIMAL ELECTRICITY. By  
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[Read Dec. 3. 1792.]

ON the 3d of November last, Sir JAMES HALL and Dr RUTHERFORD asked me to repeat with them some experiments on what has been called Animal Electricity, which were first performed by Dr GALVANI, Professor of Anatomy at Bologna, and of which an account had been communicated by Mr SEGUIN of Paris to Dr BLACK, in a letter dated Paris, 3d August.

WE accordingly, with the help of my assistant Mr FYFE, repeated them in the following manner :

WE cut a living frog into two parts, a little above the lower end of the spinal marrow. We then put the middle part of a bit of tinfoil, about one-tenth of an inch in breadth, and two inches long, under the beginning of one of the sciatic nerves, and then doubled the tinfoil over the nerve, that is, we included the nerve in the doubling of the tinfoil. We next placed one half crown silver piece between the table and loins of the frog, and another between the table and its leg. We then bended a piece of brass-wire, about the size of a common stocking-

stocking-wire, and after laying one end of it upon the half-crown piece which supported the leg, we with the other end of the wire pressed the doubled tinfoil against the half-crown piece which supported the loins, and found, that instantly convulsions were produced in the muscles of the thigh and leg.

WHEN the tinfoil was passed around both sciatic nerves, both legs were convulsed, although the half crown piece was placed under one of the legs only. These experiments were tried more than an hour after the spinal marrow had been cut across, with the same success.

IN another frog, in which the spinal marrow was not divided, we found the same means produce the same effects upon the legs, but did not observe, that the muscles above the tinfoil in the trunk or fore-legs were affected.

WHEN the touches were quickly repeated, the motions seemed to become, by degrees, less vigorous, but did not cease after repeating them often, even where the spinal marrow had been divided transversely.

ON the 10th of November, I prosecuted the subject farther by the following experiments :

#### EXPERIMENT I.

AFTER cutting off the hind legs of a living frog, I laid bare the upper part of its spinal marrow, and surrounded it with tinfoil ; and in another frog, after laying bare the brain, I thrust into it a bit of tinfoil. I then placed one half-crown piece between the table and the body of the frog, opposite to the tinfoil, and another half-crown piece between the table and the lower part of the trunk of the animal, and, on applying the wire, as before, I found convulsions produced in the fore-legs and body. Gold had nearly the same effect as silver ; but the

convulsions were much less observable, when lead, iron or copper were substituted instead of these.

## EXPERIMENT II.

I NEXT tried all the above mentioned experiments with one half-crown piece only, placed opposite to the tinfoil; and on pressing the tinfoil against the silver-piece, by means of a brass-wire which I held in my hand, I found, that the muscles were convulsed exactly in the same manner as where two pieces of the silver were employed in the manner before mentioned.

## EXPERIMENT III.

I FOUND likewise, that the experiment succeeded equally well, although the silver-piece did not touch the body of the animal, but was merely brought into contact with the tinfoil put around the nerve, by pressure with a brass-wire held in the hand.

## EXPERIMENT IV.

AFTER inclosing the upper part of the sciatic nerve in tinfoil, I tied a linen-thread around it, where it is about to pass from the trunk into the thigh, so tight as to deprive the muscles of their power of acting by the ordinary exertions of the animal, and the skin and toes of their feeling, yet when, with a brass-wire held in my hand, I pressed the tinfoil against the silver-piece, the muscles of the limb were violently convulsed.



## EXPERIMENT V.

I DIVIDED transversely all the parts of a frog at the pelvis, then tied together the divided parts of one of the sciatic nerves with a linen thread. I afterwards passed the tinfoil around the nerve, at a considerable distance above the ligature, and found, that when, with a brass-wire, I pressed the tinfoil against a half-crown piece, laid on the table at a little distance from the frog, the muscles of the leg were instantly convulsed.

## EXPERIMENT VI.

WHEN, after dividing both sciatic nerves transversely, I tied the upper part of the right sciatic nerve, inclosed in the tinfoil, to the lower part of the left sciatic nerve, and then, with a brass wire, pressed the tinfoil against a piece of silver, the muscles of the left leg were convulsed.

## EXPERIMENT VII.

THE event was the same when the divided parts of the nerves were crossed over each other, without being tied together.

## EXPERIMENT VIII.

THE event was the same, when the animal, with the metals, were placed on the top of a large glass-jar inverted, or on a plate of window-glass, supported on two pieces of sealing-wax.

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## EXPERIMENT IX.

I PASSED the tinfoil around portions of the skin, the muscles, the intestines, and around the femoral blood-vessels of frogs, without observing convulsions produced, when the tinfoil was applied to the silver by means of the brass-wire.

## EXPERIMENT X.

I LAID bare the sciatic nerve in the back part of the thigh of a young rabbit, and inclosed it in tinfoil, and then applied the tinfoil, by means of a brass wire, repeatedly to a half-crown piece, laid on the table, and observed convulsions of the leg produced on each application. I after that cut transversely the lower part of the spinal marrow, and then, with a brass-wire held in my hand, I pressed the tinfoil again to the silver, and kept it applied for a few seconds, which occasioned convulsions so quickly repeated, that the leg became rigid. Immediately thereafter, the muscles were relaxed, and their contractile power seemed to be exhausted, as repeated applications of the tinfoil to the silver produced no farther motion of the limb.

## REMARKS AND QUERIES.

FROM the accounts we have received of the experiments of Dr GALVANI and Dr VALLI, it appears, that both these celebrated authors have supposed, " That the circulation of the  
 " nervous fluid from the nerves to the muscles, is nearly similar  
 " to the circulation of artificial electricity in the Leyden phial ;

“ and as the circulation of the Leyden phial supposes two contrary electricities, the one more condensed or positive, and the other less so or negative, so Professor GALVANI concludes, that a similar distinction takes place in the bodies of animals, and that one of these electricities, to wit, the condensed or positive, is seated in the nerves, and the other in the muscles\*.”

HENCE both of them have conceived it necessary, to establish a communication between the nerve and the muscle, by means of metalline coating of the nerve and pieces of metal and metalline conductors; or by coating the nerve with lead or tin, then laying one piece of silver in contact with the tin, and another in contact with the muscle; and, in the last place, establishing a communication between the two pieces of metal, or between the nerve and the muscle, by means of a brass-wire, which they term a conductor †.

BUT, instead of this complex apparatus, I have found, from the above experiments, that the muscle is thrown into action, although no metal is directly in contact with it, or when the communication between the metals and the muscle is made by the nerve alone.

It appears therefore, that Professor GALVANI and Dr VALLI have allowed preconceived theory to conduct their experiments, instead of allowing their experiments to conduct their theory; in consequence of which, several of their experiments have been performed with less accuracy than might have been expected. Thus, they tell us, that if the conductor is first applied to the muscle, the convulsions are stronger than when it is first applied to the nerve; that the shocks are stronger when the feet communicated with the earth, &c. whereas the application of the conductor to the muscles, or of the feet to the earth, are quite out of the question.

2. WE

\* See Medical Facts and Observations, Lond. 1792. p. 187, 188.

† Ditto, p. 187. 191. 211.



2. WE have found, that when a piece of silver is brought in contact with the tinfoil coating of a nerve, the muscles in which that nerve terminates, are thrown into action, although the nerve has been surrounded with a tight ligature between the coating and the muscle, or even although it has been divided by a transverse incision, provided the divided parts are again brought into contact, or tied together by a thread.

3. WHEN we tie the coated nerve, after it is cut transversely, to another nerve which has been cut transversely, we have found, that the muscles supplied by the latter are thrown into action.

4. AFTER the spinal marrow and whole body of the frog were divided transversely about the middle of the back, and the tin coating and silver were applied to the sciatic nerve, I did not observe, that the muscles at the loins and pelvis were thrown into action, or the effect produced by the metals did not influence muscles supplied by branches of nerves sent off from the spinal marrow or sciatic nerves above the coating.

IT appears, that the nerve of a living animal, whether entire, or cut and rejoined, conducts that matter by which the muscle is influenced more readily than the skin, the flesh or the blood-vessels do.

5. ALTHOUGH, on repeating Dr GALVANI's experiments, it should be proved, that electrical matter, drawn from a cloud or excited by the common machinery, and conducted to a nerve, and that matter, which is put in motion by the application of certain metals to each other and to a nerve, produce similar motions in the muscles in which the nerve terminates, we are not at liberty to take for granted, as GALVANI and VALLI seem to have done, that the electrical matter and this matter are the same, as the nerves may be affected by stimuli of different kinds.

6. As an animal does not feel nor act by the medium of a nerve which has been divided transversely, although its divided parts are placed contiguous, or tied together; as the muscles supplied by nerves above the place coated are not thrown into action; the above experiments, or those of GALVANI and VALLI, instead of proving, as they have supposed, that the matter which is excited is electrical, and the fluid of the nerves the same with it, appear to show, that the electrical fluid, or matter put in motion by the different metals, is quite different in its nature from the nervous fluid, as the course of the nervous fluid, but not that of the electrical, can be intercepted by ligature or incision of the nerve.

7. As the action of the muscles, in the above experiments, is not produced, nor even increased, by connecting the coating of the nerve with the muscle by means of a wire, there is no foundation for the opinion of GALVANI and VALLI, that the nerve is electrified plus, and the muscle minus, or that the electricity of the one is positive, and that of the other negative.

8. We seem therefore to be led to the conclusion, that the matter or fluid which is excited or put in motion by the application of the different metals to each other, and to the nerve, serves merely as a powerful stimulus to that energy or fluid which is lodged in the nerves.

To support this way of reasoning, we may observe, that in a warm blooded animal, the rabbit, although convulsions were repeated for a considerable length of time when the nerve was entire, yet, after dividing the nerve and intercepting the further supply of nervous energy from the brain, the action of the muscles ceased in a few seconds, by keeping the two metals contiguous, which is readily explained on the supposition, that the nervous energy or fluid, lodged in the nerve beyond the

place of the incision, was exhausted; and Dr VALLI himself, by observing, that, after the electricity, as he calls it, of a limb is exhausted, if the coating of a nerve be moved higher up, the action of the muscles may be renewed\*, furnishes a fact which, I apprehend, may be explained on the same principle.

\* Medical Facts and Observations, Art. xx. p. 218.

F I N I S.

